OK TO ENTER: /D.G.D./ 01/28/2011

Appl. No.: 10/550,770

Amdt. Dated January 25, 2011

AMENDMENTS TO THE SPECIFICATION:

Please amend the specification by replacing the Summary of the Invention Section, namely Paragraphs [0037] through [0063] as numbered in the published version of this application, U.S. Pat. App. Pub. No. 2007-0019968 A1 (shown on page 5, line 13 through page 11, line 28 of the original specification), with the following Replacement Summary of the Invention Section, (Paragraphs [0037] through [0063]), marked to show changes relative to the original version.

[0037] In order to solve the above described objects, the invention ~~related to claim 1~~ provides a method for controlling bias of optical modulator for controlling the DC bias of each of a plurality of optical modulating sections of an optical modulator comprising an optical waveguide formed on a substrate with an electro-optic effect, and said plurality of optical modulating sections for modulating optical waves propagating through said optical waveguide, the optical modulator being configured so as to combine the optical waves modulated by said plurality of optical modulating sections, comprising the steps of: superposing a low frequency electrical signal with a specific frequency on a modulating signal or a DC bias applied into each of said plurality of optical modulating sections; detecting the change of light intensity corresponding to said low frequency electrical signal from the optical wave after being combined; and controlling the DC bias of each optical modulating section based on said detected change of light intensity.

[0038] In addition, the invention ~~related to claim 2~~ provides the method for controlling bias of optical modulator ~~according to claim 1~~, wherein said specific frequency differs between each optical modulating section.

[0039] In addition, the invention ~~related to claim 3~~ provides the method for controlling bias of optical modulator ~~according to claim 2~~, wherein said different frequencies are made not to be an integral multiplication of each other.

[0040] In addition, the invention ~~related to claim 4~~ provides the method for controlling bias of optical modulator ~~according to claim 1~~, wherein said low frequency electrical signal is superposed at different times on each optical modulating section.

[0041] In addition, the invention ~~related to claim 5~~ provides a method for controlling bias of optical modulator for controlling the DC bias of each of a plurality of optical modulating sections of an optical modulator comprising an optical waveguide formed on a substrate with an electro-optic effect, and said plurality of optical modulating sections for modulating optical waves propagating through said optical waveguide, the optical modulator being configured so as to combine the optical waves modulated by said plurality of optical modulating sections, comprising the steps of: superposing a low frequency electrical signal with a specific frequency on a modulating signal or a DC bias applied into at least one of said plurality of optical modulating sections; detecting the change of light intensity corresponding to said low frequency electrical signal from the optical wave exiting from the optical modulating section, into which said modulating signal or said DC bias superposed with said low frequency electrical signal is applied; and controlling the DC biases of all or some of said plurality of optical modulating sections based on said detected change of light intensity.

[0042] In addition, the invention ~~related to 6~~ provides the method for controlling bias of optical modulator ~~according to claim 5~~, wherein said control of the DC biases of all or some of said plurality of optical modulating sections is performed by determining a controlled variable with respect to each optical modulating section based on said change of light intensity.

[0043] In addition, the invention ~~related to claim 7~~ provides a device for controlling bias of optical modulator for controlling the DC bias of each of a plurality of optical modulating sections of an optical modulator comprising a substrate with an electro-optic effect, an optical waveguide formed on said substrate, said plurality of optical modulating sections for modulating optical waves propagating through said optical waveguide, and a combining element provided for said optical waveguide for combining the optical waves modulated by said plurality of optical modulating sections, further comprising: a DC bias application means for applying a DC bias into each of said plurality of optical modulating sections; a low frequency electrical signal superposing circuit for superposing a low frequency electrical signal with a specific frequency on a modulating signal or a DC bias applied into each of said plurality of optical modulating sections; an optical detecting means for detecting the change of light intensity of the optical wave passing through said combining element; and a bias controlling means for extracting the change of light intensity corresponding to said low frequency electrical signal from said optical detecting means and also for controlling said DC bias application means based on said extracted change of light intensity.

[0044] In addition, the invention ~~related to claim 8~~ provides the device for controlling bias of optical modulator ~~according to claim 7~~, wherein said low frequency electrical signal superposing circuit comprises a plurality of low frequency electrical signal generation elements for generating the low frequency electrical signal respectively corresponding to the plurality of optical modulating sections.

[0045] In addition, the invention ~~related to claim 9~~ provides the device for controlling bias of optical modulator ~~according to claim 7~~, wherein said low frequency electrical signal superposing circuit comprises one low frequency electrical signal generation element for generating the low frequency electrical signal, and switches the low frequency electrical signal generated from said low frequency electrical signal generation element to supply the low frequency electrical signal to each optical modulating section.

[0046] In addition, the invention ~~related to claim 10~~ provides a device for controlling bias of optical modulator for controlling the DC bias of each of a plurality of optical modulating sections of an optical modulator comprising a substrate with an electro-optic effect, an optical waveguide formed on said substrate, said plurality of optical modulating sections for modulating optical waves propagating through said optical waveguide, and a combining element provided for said optical waveguide for combining the optical waves modulated by said plurality of optical modulating sections, further comprising: a DC bias application means for applying a DC bias into each of said plurality of optical modulating sections; a low frequency electrical signal superposing circuit for superposing a low frequency electrical signal with a specific frequency on a modulating signal or a DC bias applied into at least one of said plurality of optical modulating sections; an optical detecting means for detecting the change of light intensity corresponding to said low frequency electrical signal from the optical wave exiting from the optical modulating section, into which said modulating signal or said DC bias superposed with said low frequency electrical signal is applied; and a bias controlling means for extracting the change of light intensity corresponding to said low frequency electrical signal from said optical detecting means and also for controlling said DC bias application means of all or some of said plurality of optical modulating sections based on said extracted change of light intensity.

[0047] In addition, the invention ~~related to claim 11~~ provides the device for controlling bias of optical modulator ~~according to any one of claims 7 to 10~~, wherein said optical detecting means detects the optical wave emitted from said optical waveguide into said substrate.

[0048] In addition, the invention ~~related to claim 12~~ provides the device for controlling bias of optical modulator ~~according to any one of claims 7 to 10~~, wherein said optical detecting means detects the optical wave guided out by a directional coupler positioned adjacent to said optical waveguide.

[0049] In addition, the invention ~~related to claim 13~~ provides the device for controlling bias of optical modulator ~~according to any one of claims 7 to 10~~, wherein said optical detecting means detects the optical wave, which exits from said optical modulator and is thereafter branched by an optical branching means.

[0050] In addition, the invention ~~related to claim 14~~ provides the device for controlling bias of optical modulator ~~according to any one of claims 11 to 13~~, wherein said optical detecting means comprises at least two optical detectors or more.

[0051] In accordance with the method described above ~~invention related to claim 1~~, by applying the specific low frequency electrical signal into each optical modulating section and detecting the change of light intensity corresponding thereto, it becomes possible to easily understand the state of the drift phenomenon of each optical modulating section. Further, control of the DC bias of each optical modulating section becomes possible even while using the optical modulator without complicating the optical modulator and bias controlling circuit too much.

[0052] In accordance with the invention ~~related to claim 2~~, it is possible to understand the state of the drift phenomenon of each optical modulating section with respect to each frequency

electrical signal corresponding to each optical modulating section. Moreover, because the low frequency electrical signals applied into the plurality of optical modulating sections respectively have different frequencies, it is possible to understand the behaviors of the plurality of optical modulating sections at the same time.

[0053] If the different frequencies are the integral multiplication of each other when understanding the state of the drift phenomena of the plurality of optical modulating sections at the same time, the problem could occur that an input/output characteristics change due to the low frequency electrical signal applied into the other optical modulating sections than the focused optical modulating section is detected as the characteristic of said focused optical modulation section. It is possible to solve such problem in accordance with the invention ~~related to claim 3~~.

[0054] In accordance with the invention ~~related to claim 4~~, control of the biases of the plurality of optical modulating sections becomes possible by delaying the timing of superposition even when there are only one or a few kinds of frequencies of the low frequency electrical signal.

[0055] In accordance with the method described above ~~invention related to claim 5~~, the specific low frequency electrical signal is applied into at least one of the plurality of optical modulating sections to detect the change of light intensity corresponding to said low frequency electrical signal from the optical wave exiting from said optical modulating section. Then, based on said detected change of light intensity, the DC biases of the other optical modulating sections as well as the DC bias of said optical modulating section are controlled. Thus, it becomes unnecessary to superpose the low frequency electrical signal or to detect the output optical wave corresponding to each optical modulating section. This enables the DC bias of each optical modulating section to be easily kept in an adequate state without complicating the whole structure of the optical modulator. Further, the DC bias of each optical modulating section can be controlled even while the optical modulator is used.

[0056] The correlation between the drift phenomenon of the optical modulating section, into which the low frequency electrical signal is applied, and the drift phenomena of the other optical modulating sections is preliminarily determined by the design of the optical modulator, the characteristic measurement of each optical modulator, or the like. Then, it becomes possible to determine the controlled variable of each optical modulating section in reference to said correlation based on the change of light intensity of the optical modulating section into which the low frequency electrical signal is applied. In accordance with the invention ~~related to claim 6~~, only by measuring the drift phenomena of some optical modulating sections, it becomes possible to adequately keep the controlled variable of each optical modulating section. Then, effective control becomes possible even while using the optical modulator without complicating the control mechanism of the optical modulator.

[0057] In accordance with the invention ~~related to claim 7~~, by applying the specific low frequency electrical signal into each optical modulating section and detecting the change of light intensity corresponding thereto ~~as stated in claim 1~~, the state of the drift phenomenon of each optical modulating section can be easily understood. Moreover, control of the DC bias of each optical modulating section becomes possible even while using the optical modulator without complicating the optical modulator and bias controlling circuit too much.

[0058] Especially in accordance with the invention ~~related to claim 8~~, because the frequencies of the low frequency electrical signals applied respectively into the plurality of optical modulating sections are different, it is possible to understand the behaviors of the plurality of optical modulating sections at the same time. In addition, in accordance with the invention ~~related to claim 9~~, the biases of the plurality of optical modulating sections can be controlled by switching and supplying the low frequency electrical signal to each optical modulating section even when the low frequency electrical signal has only one frequency.

[0059] In accordance with the invention ~~related to claim 10~~, it becomes unnecessary to superpose the low frequency electrical signal or to detect the output optical wave corresponding to each optical modulating section and becomes possible to easily keep the DC bias of each optical modulating section in an adequate state without complicating the whole structure of the optical modulator ~~like claim 5 or claim 6~~. Further, control of the DC bias of each optical modulating section is possible even while using the optical modulator. Moreover, by preliminarily determining the correlation between the drift phenomenon of the optical modulating section, into which the low frequency electrical signal is applied, and the drift phenomena of the other optical modulating sections, it becomes possible to adequately control the DC bias of each optical modulating section by setup and arrangement of the bias controlling means.

[0060] For the optical modulator, the optical wave called stray light is emitted into the substrate from the combining element or the like of the optical waveguide. In accordance with the invention ~~related to claim 11~~, said optical wave is effectively used to prevent deterioration of a signal light without detecting the signal light directly or one portion of it, the signal light exiting from the optical modulator.

[0061] In accordance with the invention ~~related to claim 12~~, it is possible to anywhere detect the optical wave propagating through the optical waveguide on the substrate by using the directional coupler. Further, because the directional coupler can be formed by the same process as the optical waveguide on the substrate, it is possible to form it at the same time as the optical waveguide.

[0062] In accordance with the invention ~~related to claim 13~~, because a light signal exiting from the optical modulator is directly detected, it becomes possible to accurately understand the

input/output characteristics of the whole optical modulator or each optical modulating section. Moreover, even when it is difficult to place the optical detector adjacent to the optical modulator, an optical branching means, such as a branching waveguide, polarization beam splitter and photo coupler, is used for an optical path, such as an optical fiber, that guides the outgoing light from the optical modulator to the exterior, to thereby enable optical detection anywhere.

[0063] In accordance with the invention ~~related to claim 14~~, the plurality of optical detectors are placed corresponding to the plurality of optical modulating sections to decrease the number of optical modulating sections assigned to one optical detector. Thus, it is possible to select the optical detector in accordance with the frequency of the low frequency electrical signal. This increases the range of said frequency choices while the burden on the circuit for extracting the change of light intensity corresponding to each low frequency electrical signal can be reduced.